ABSTRACT OF SUMMARY REPORT ON RESEARCH AND DEVELOPMENT IN THE FIELD OF ARTIFICIAL LIMBS[a]

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This report discusses progress from July 1, 1969, through June 30, 1970, in the development of lower-extremity prostheses, sponsored by the Prosthetic and Sensory Aids Service of the Veterans Administration. Work on four items has been underway: two hydraulic knee mechanisms including development work toward an improved setup, one hydraulic ankle mechanism including lateral motion foot control and transverse rotation, and studies toward a voluntarily actuated swing- and stance-control mechanism. The purpose of these developments is to provide as many as possible of the lost muscle functions in the artificial joints involved, without exceeding reasonable limits regarding cost, weight, complexity, and maintenance needs.

A limited production run of the new shortened strapless *Swing Control (Type S) System* was completed in October 1969 and the distribution was started. The development of this unit is now complete. Reporting will therefore be discontinued.

The first production run of the *Swing and Stance Control (Type S–N–S) System* was completed July 22, 1969. Distribution was started shortly thereafter.

A great deal was learned during this production run and, as a result, a number of changes have been incorporated in both the Type S–N–S and Type S Systems.

A Manual covering the Type S–N–S as well as the Type S System, which also includes a chapter on Training, was completed in July 1969.

The distribution of the S–N–S System continued throughout the reporting period without difficulties or major findings. A small number of suggestions from the field and six minor findings were incorporated in the design of the system.

The demand for this type system is larger than expected, and spon-

[a] Based on work performed under VA Contract V1005M–1412.

taneous letters of satisfaction and even enthusiasm are being received from the field. It seems that the function of the Type S–N–S System fills a real need for amputees of all age groups.

As a result, demand for the Type S–N–S Systems increased at such a rate that a delivery gap of approximately 6 weeks will develop for the VA and this laboratory before the systems from the next production run will become available.

In view of the second production run, a number of minor production engineering modifications were included in the design of this system.

In order to be able to use in further production runs several of the commercially available standard wooden setups, a study was initiated during October 1969 with the goal of identifying those modifications which could be applied to any standard setup and which would result in a final product technically equivalent to, and possibly cheaper than, the present setup. The study was successfully concluded in March 1970 with the result that there are now two sources for the setup.

Work on the *Hydraulic Ankle Control Unit* was resumed fully in November 1969 and has been proceeding ever since with high priority. As reported in the last annual Summary Report dated June 30, 1969, rather than going ahead with all eight production prototype units, it was decided to complete one of them first in order to test the design changes introduced during the past contract year.

In carrying out and testing these design changes, the need for additional modifications and improvements became apparent. At the end of the report period the following major changes had been arrived at, often after several in-between steps and extensive testing:

The problem of the lever arrangement for the plantar-flexion springs was finally solved by making the lever itself, and the surfaces against which it works, of hardened steel. Incorporating this lever into the design also provided more space for the plantar-flexion springs, which were redesigned to reduce stress and to lengthen fatigue life.

A number of changes became necessary to decrease or eliminate noises. Some of these changes concerned the attachment of the hydraulic unit to the foot and to the shank of the artificial leg. In redesigning the shank attachment to eliminate noise, other improvements were included with the purpose of reducing wear, improving accessibility, and accommodating future pylon-type shanks. Certain noises produced inside the hydraulic system required extensive studies and significant modifications of the hydraulic mechanism.

A major effort was devoted to the optimization of the toe-slap damping. Several approaches proved unsatisfactory. The final design which our amputee found highly acceptable necessitated the addition of a U-seal around the piston for the front chamber, the use of hardened steel

sliding surfaces instead of aluminum and other metals, and the addition of a ring-shaped bypass orifice which gradually closes during plantar flexion.

As a result of the foregoing changes, which eliminated all the known shortcomings, our amputee accepted this design for routine wear in July 1969. If the favorable results continue, we will complete the remaining parts of a second shakedown test model and will install the assembled unit into a prosthesis to be provided by VAPC, New York.

Theoretical work on the *Voluntarily Actuated Swing and Stance Control Unit* has been delayed by more pressing problems, but will be continued with higher priority from now on. Significant results were achieved regarding an electrical feedback of the shank position by skin stimulation, and regarding the valve arrangement for the control of swing as well as stance resistances. It seemed possible, by the use of a single solenoid, to produce all the necessary gradual changes of these resistances without resorting to servo-effects or fluidics, and without exceeding reasonable limits regarding power requirements. Continued studies resulted in a tentative design involving the use of a Ledex solenoid size #1 which is particularly suited for this application.